TPC R&D at BNL

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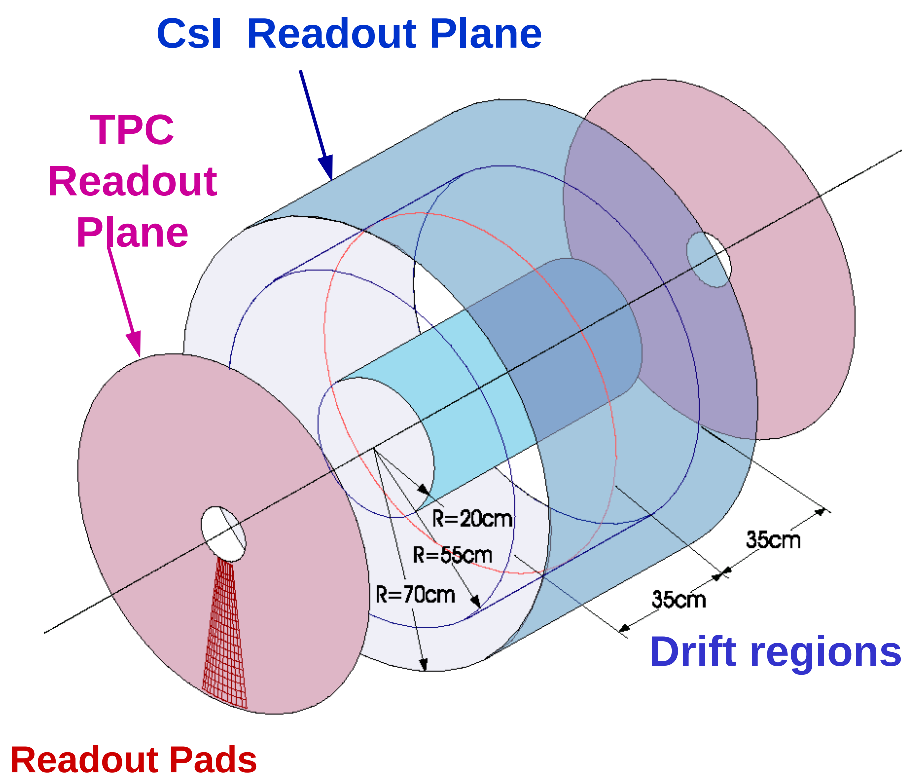
BNL

TPC Workshop

June 1, 2015

Original TPC/HBD Detector Proposal for PHENIX (circa ~ 2004)



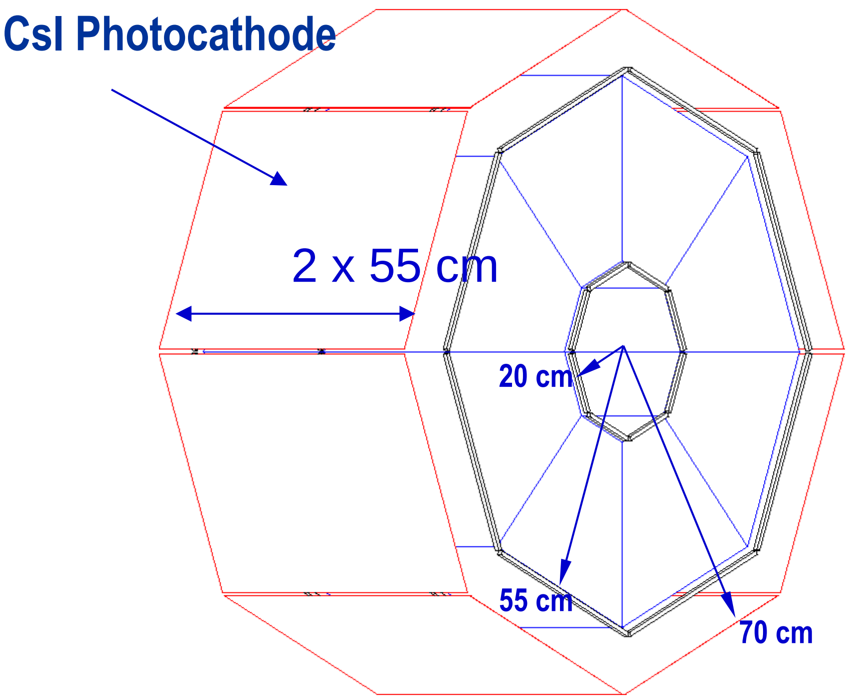
- TPC provides momentum measurement and particle id through dE/dx. Use ionization in gas volume to measure track trajectory.
- Cherenkov provides particle id as a threshold counter. Measure Cherenkov light produced in gas volume to identify high velocity particles (e.g., electrons)

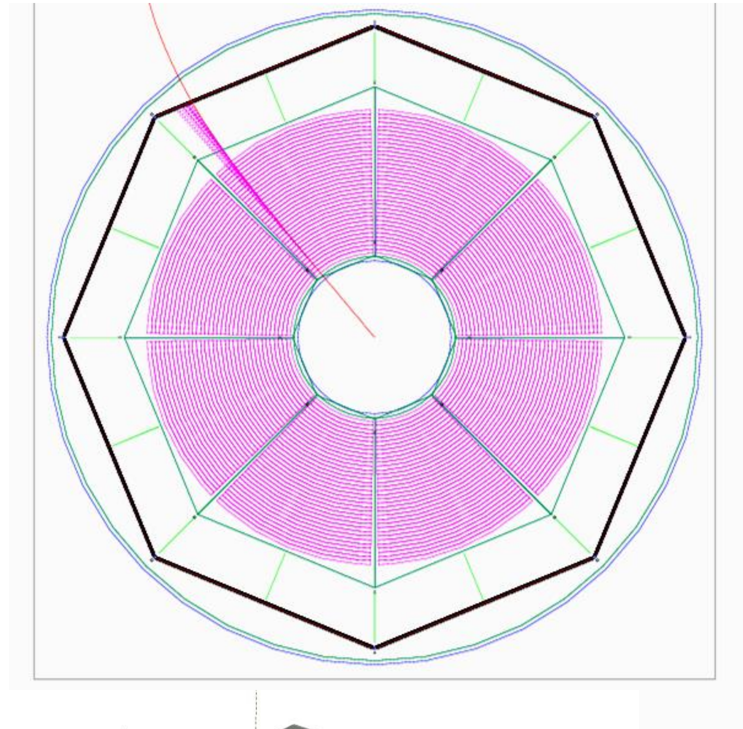
  (could even be a RICH, but that becomes much more difficult)

Fast, Compact TPC

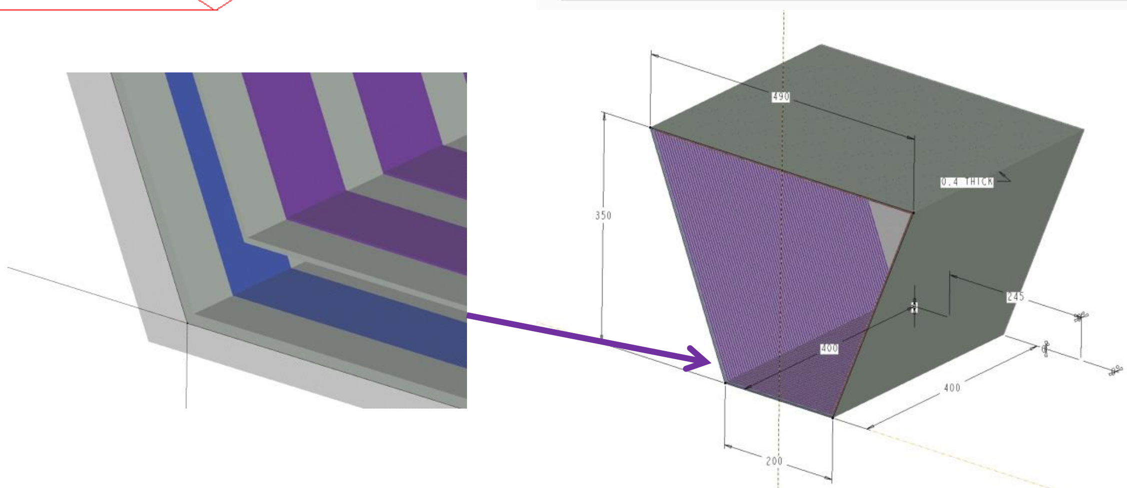
R<70 cm, L< 80 cm, T_{drift} < 4 μsec

Previous Design Study





Field cage for sectors

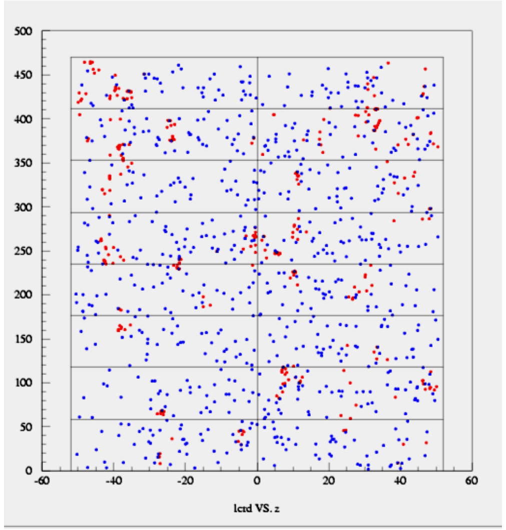


N. Smirnov

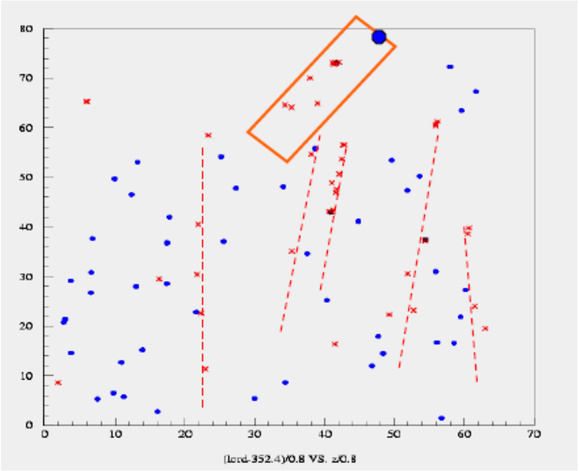
Previous Simulations

Finding electrons in central HIJING events
using TPC to identify hits on Cherenkov plane

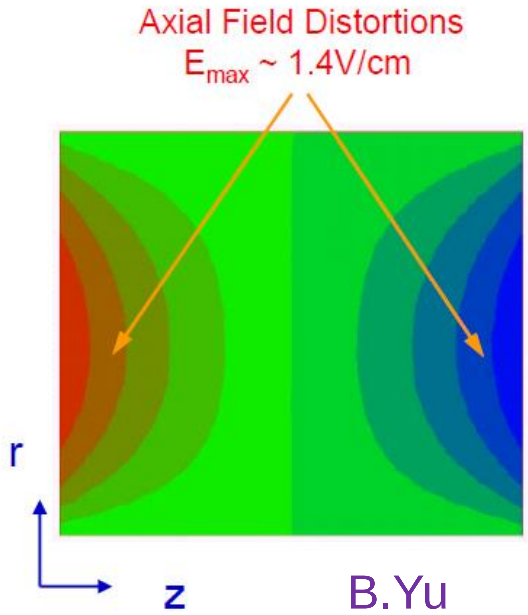
Rϕ All hits



Rϕ Cherenkov Hits

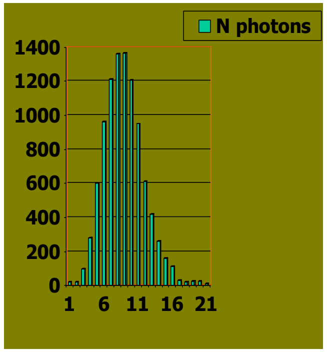


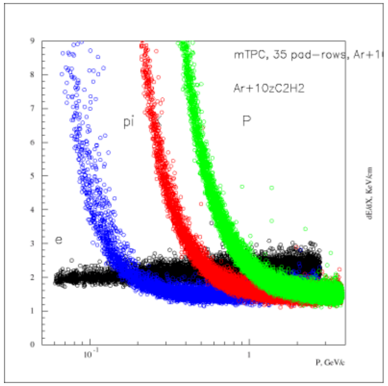
Space Charge Effects
Central Au+Au

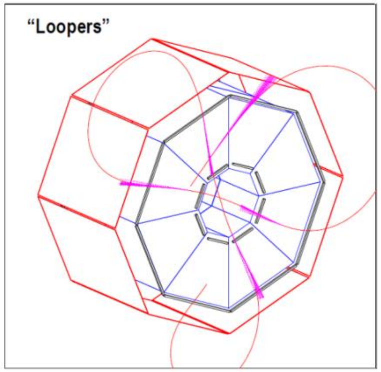


B.Yu

θ ~ 2.5 x 10^{-3} rad
Δx ~ 0.5 mm for 40 cm drift





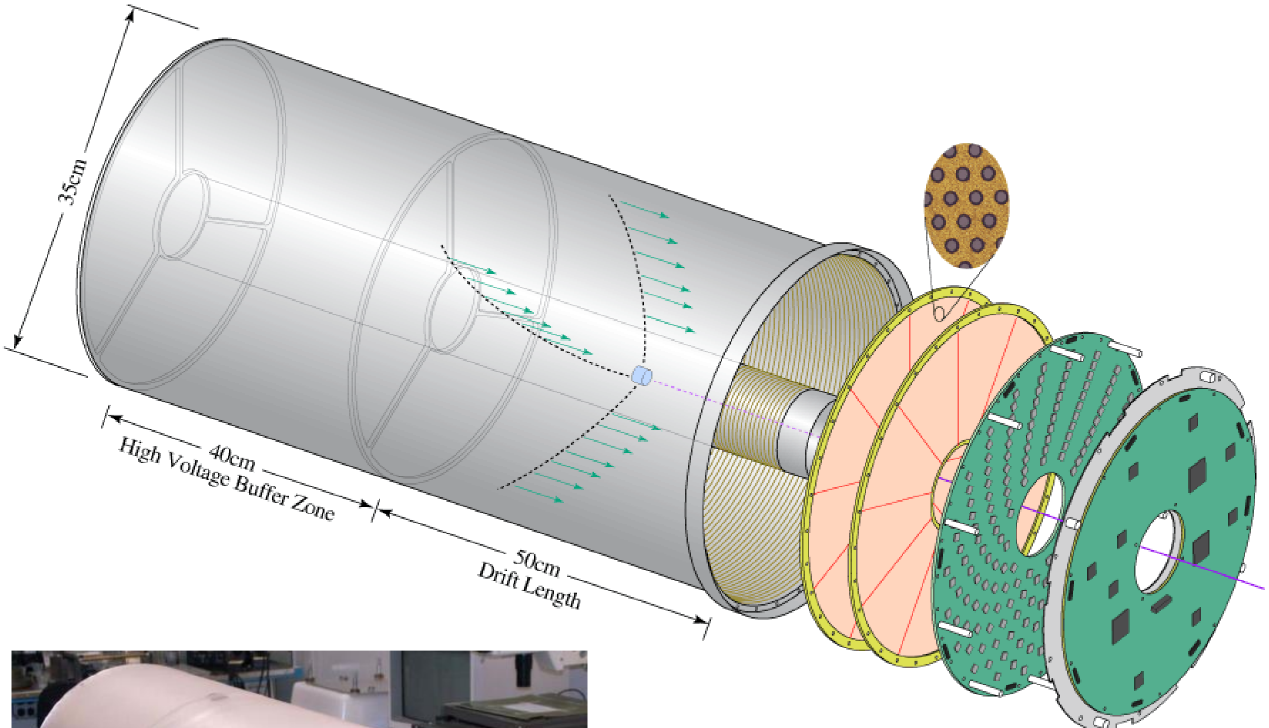


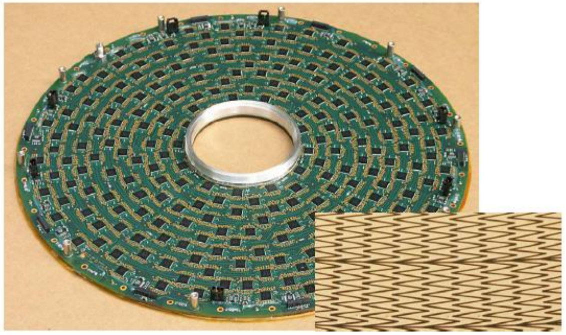
C.Aidala

N. Smirnov

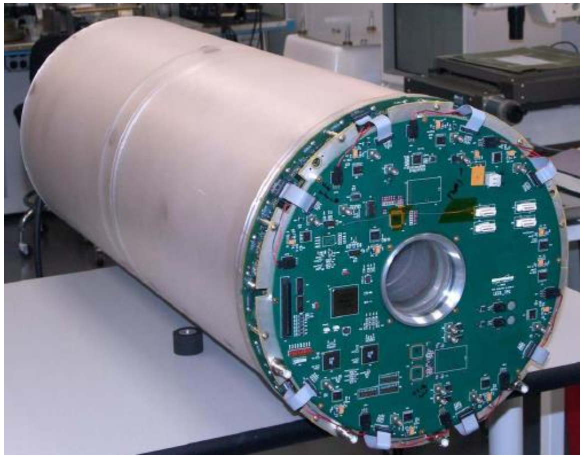
LEGS TPC (circa ~ 2005)

- Designed for low rate (~kHz), low multiplicity (single sample per channel per trigger)
- Inner diameter ~9cm; Outer diameter ~35cm; Drift Length: 50cm





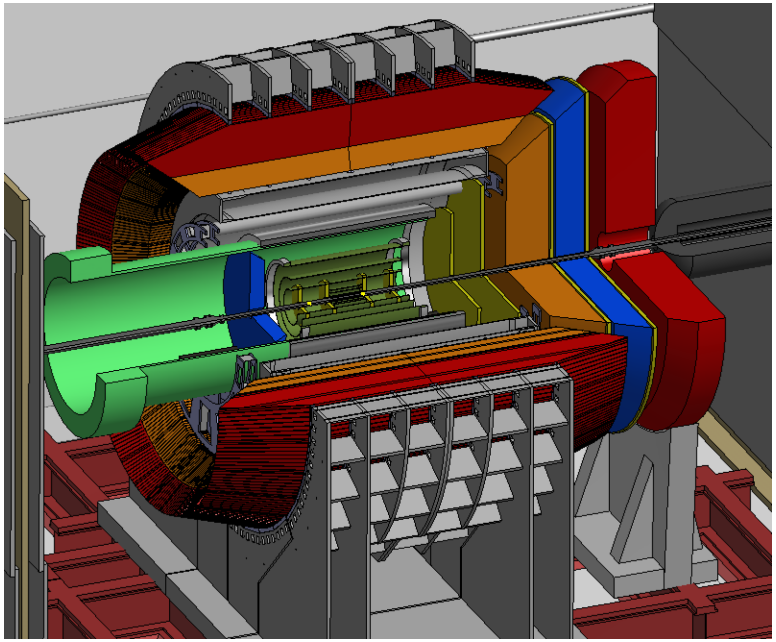
- Chevron pad readout (~ 200 µm resolution)
- ~ 7K Readout channels
- Custom ASIC
  32 channels per chip
  40mW per chip
- ENC < 250 e's
- 500ns peaking time
- Single peak time and amplitude measurement
- Timing resolution ~ 20ns



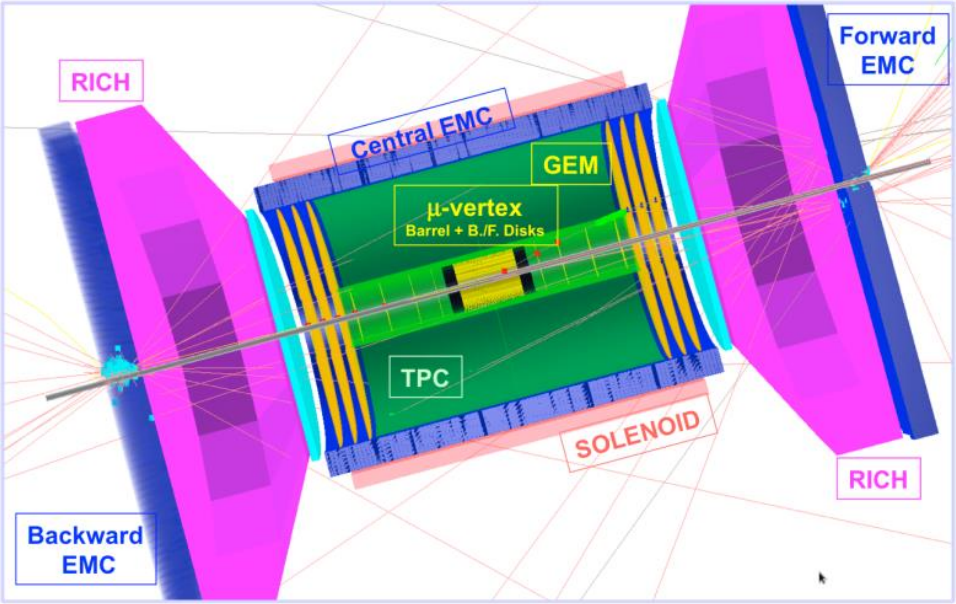
- Double GEM (G <1000)
- Drift field ~ 600V/cm (30kV HV)
- Drift time ~ 5µs

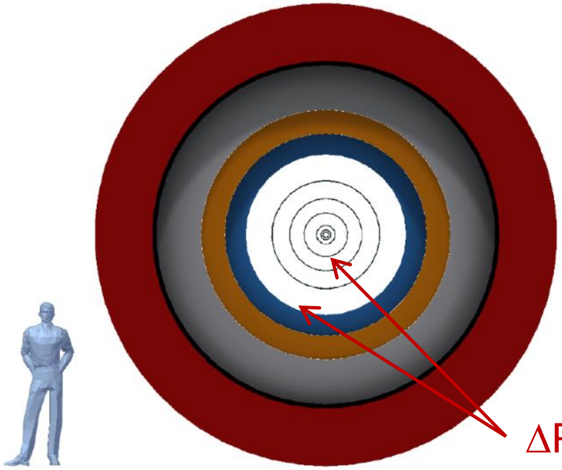
Use at RHIC and EIC

sPHENIX



BEAST





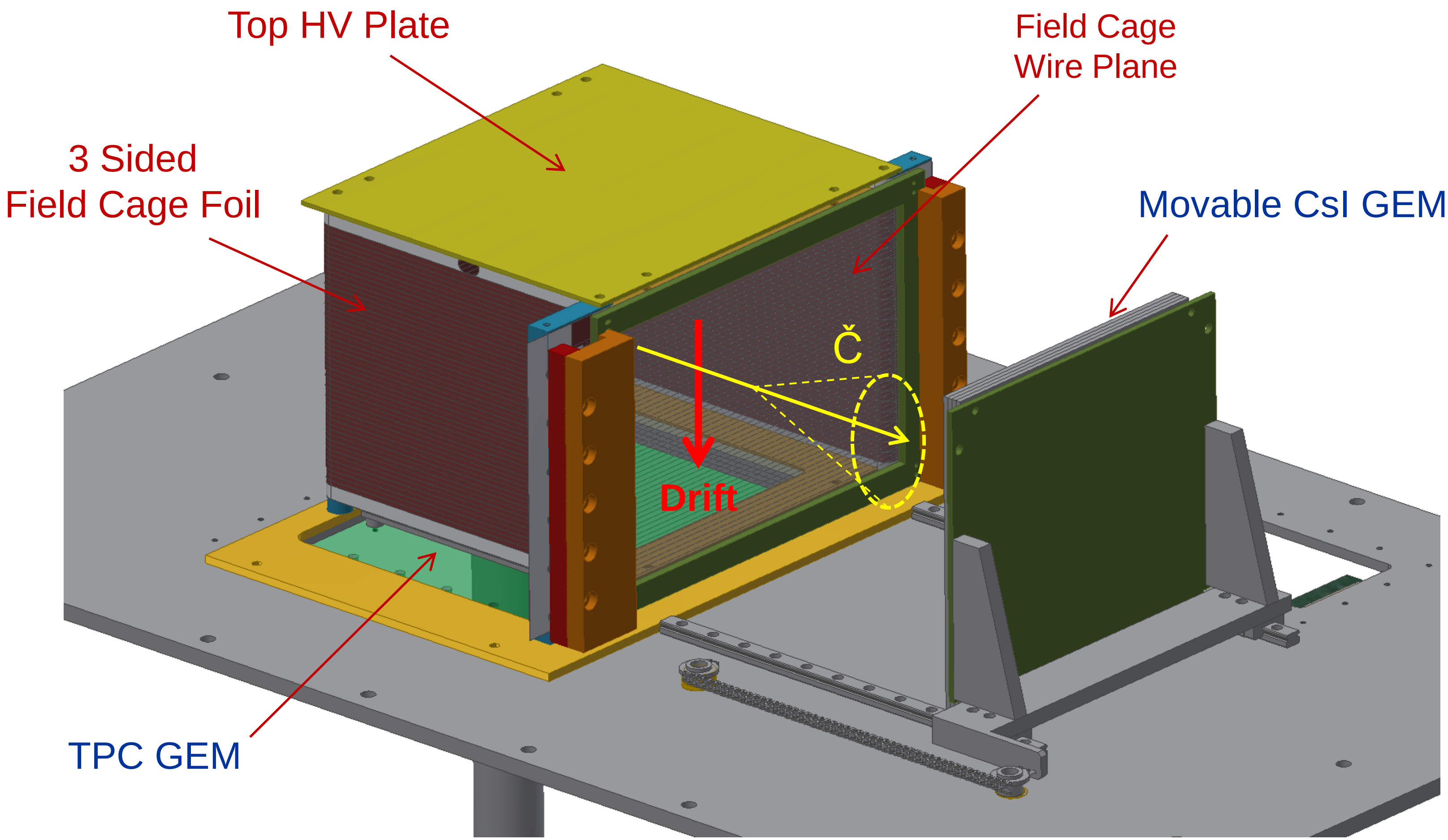
ΔR for TPC Tracking ~ 30-80 cm

Used to improve electron id in the central region along with dE/dx

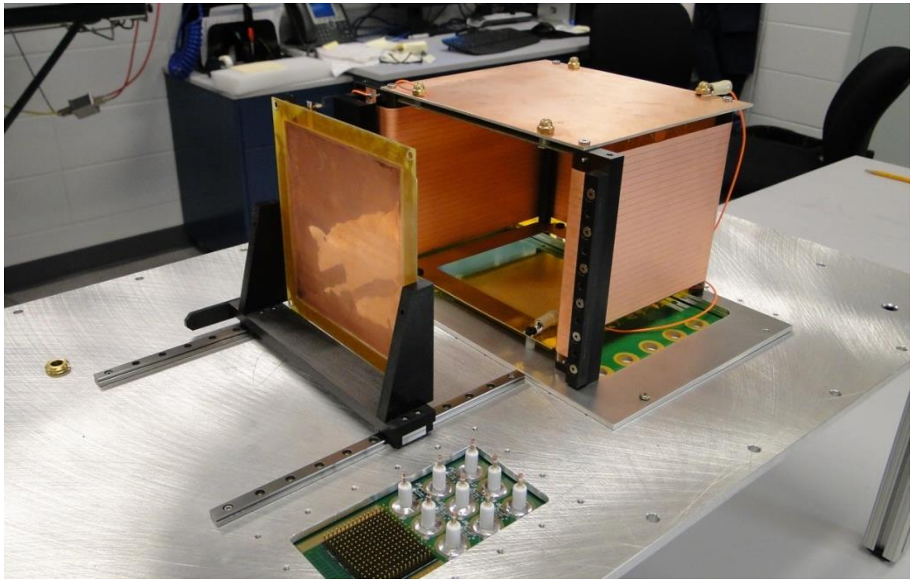
Detector Requirements

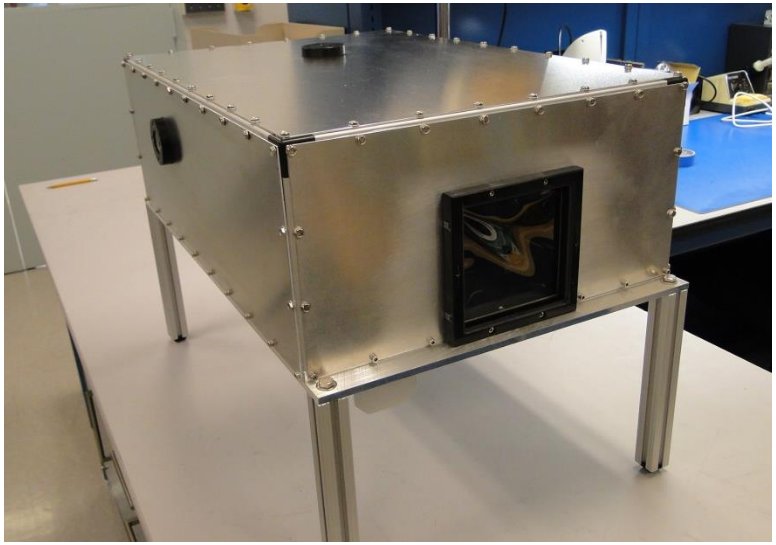
- Gas must be transparent to UV light $\longrightarrow CF_4$ (like HBD)
- Want fast drift velocity ($\longrightarrow CF_4$ or mixtures containing CF_4)
- Photosensitive GEM must operate near the HV plane of the field cage. Field cage must be optically transparent on its outer radius. How much radial space with it take up ?
- What are space charge limitations if used in HI collisions ?

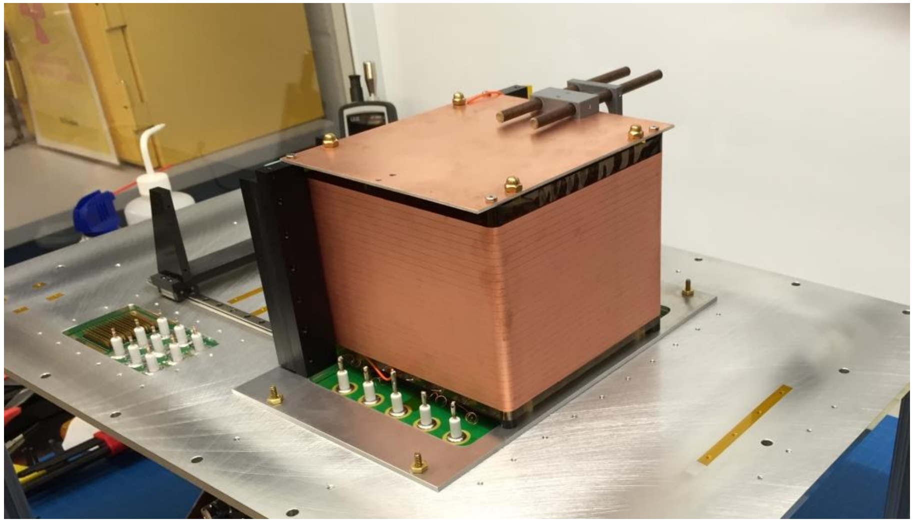
3D Detector Model



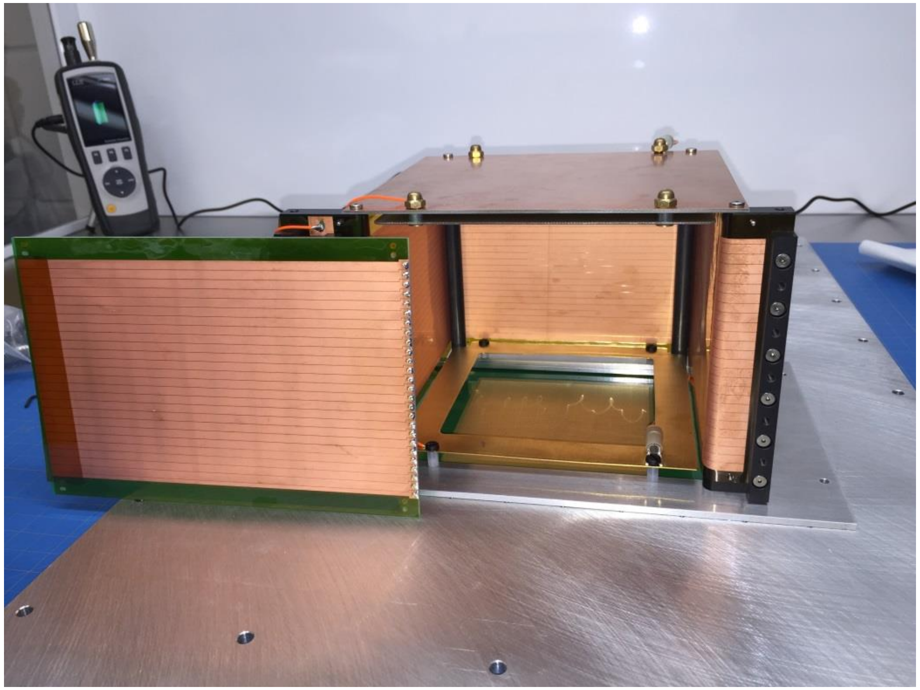
The Actual Prototype

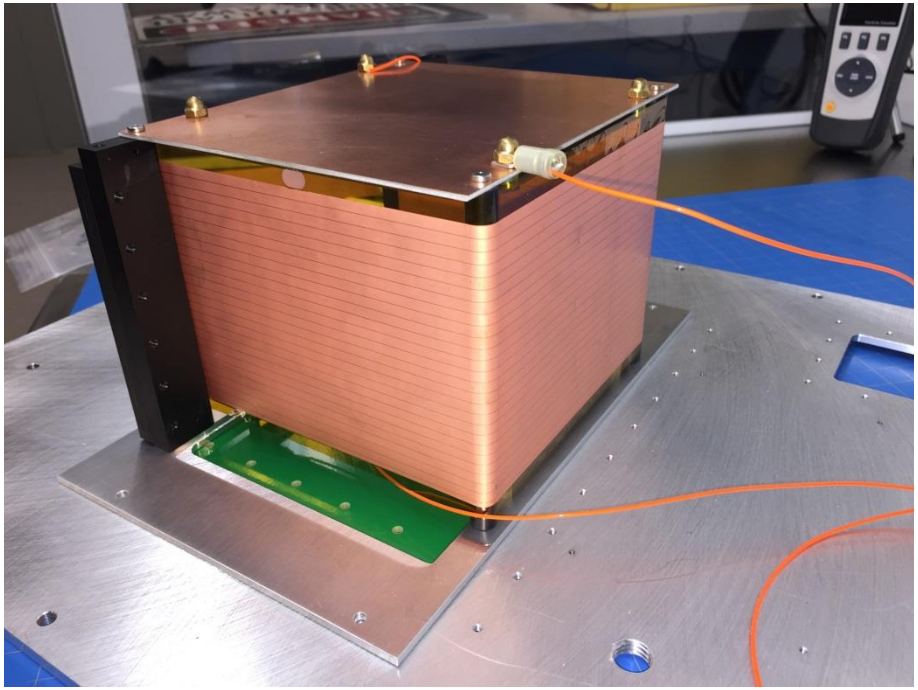






3 Sided Field Cage + 1 Sided Foil

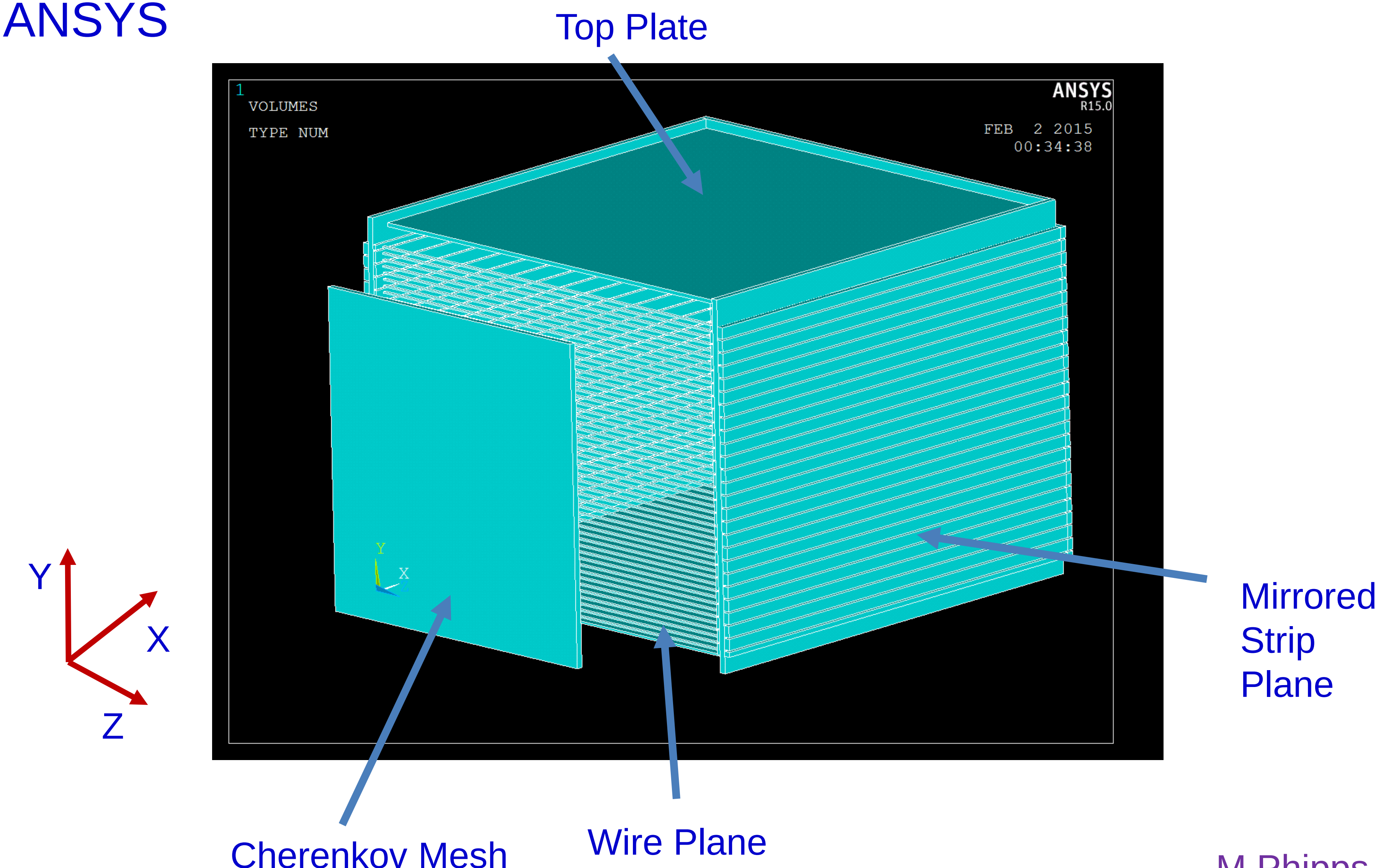




Kapton foil with 3.9 mm copper strips with 0.1 mm gaps
Tested to full operating voltage of 1 kV/cm

Electrostatic Simulation

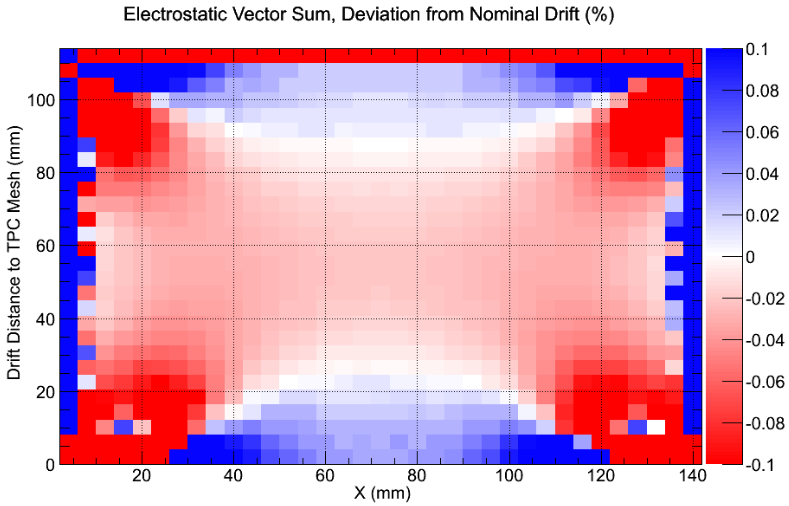
ANSYS



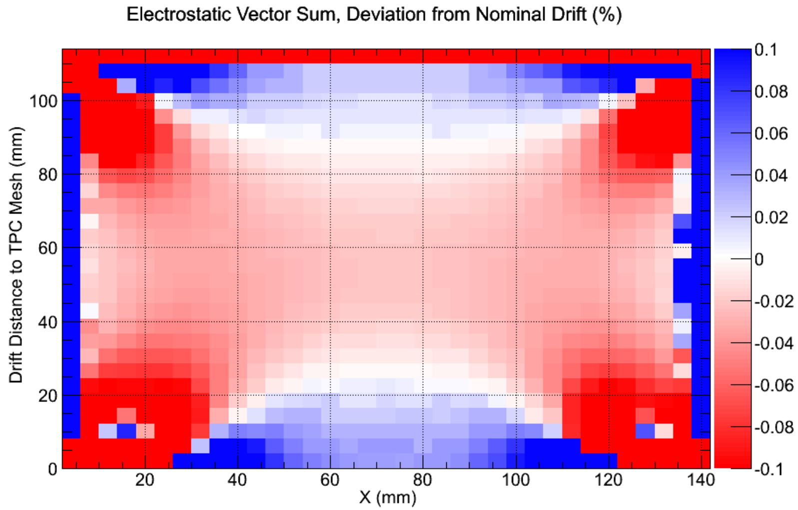
M.Phipps

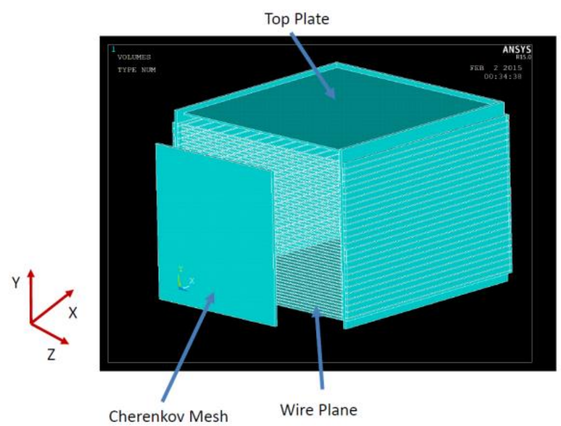
Field Distortions with One Plane of Wires for Field Cage

4 sides of strips



3 sides of strips + 1 side of wires





Slice in XY plane at mid Z
Wire plane is at X=0

M.Phipps

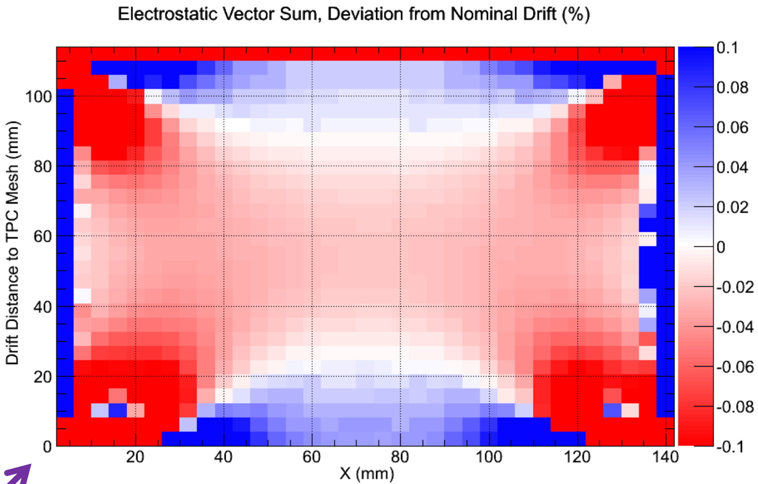
Field Distortions with Addition of Cherenkov Mesh

0.1% Scale

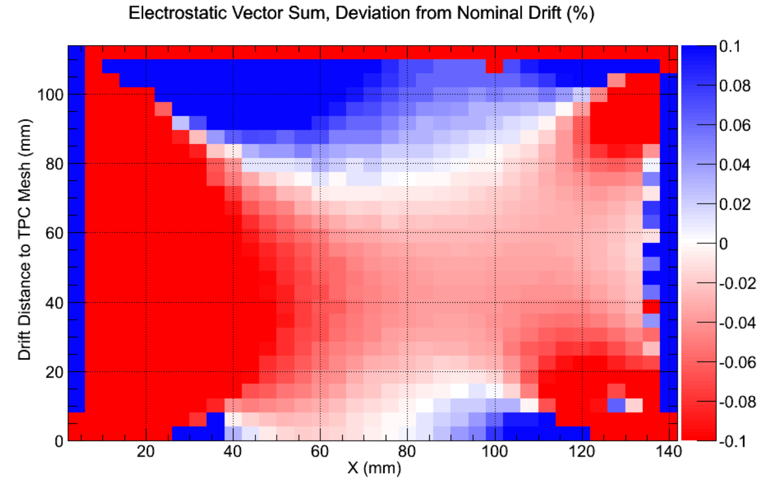
Drift

Wires

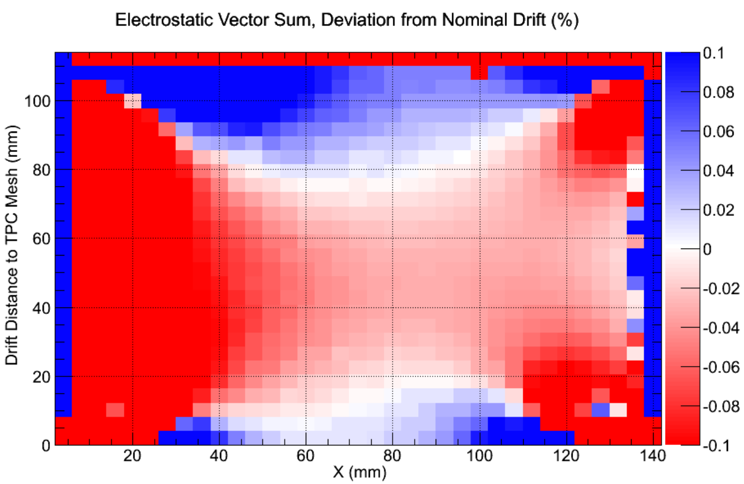
No Cherenkov mesh



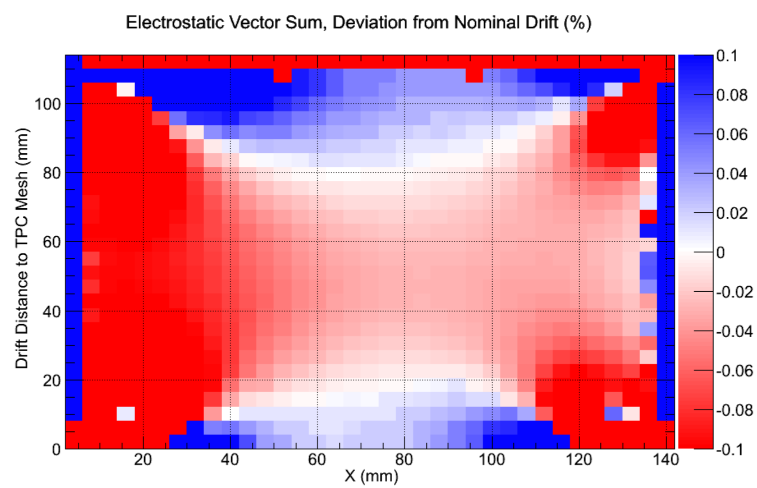
Cherenkov mesh @ -15 mm



Cherenkov mesh @ -25 mm



Cherenkov mesh @ -40 mm



M.Phipps

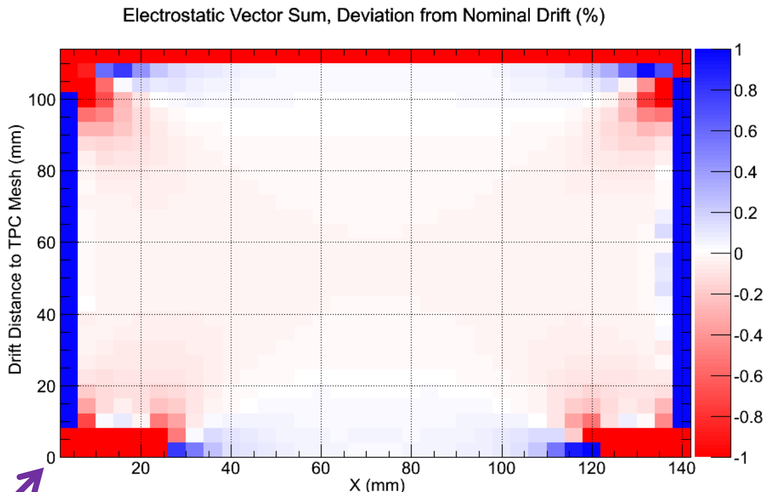
Field Distortions with Addition of Cherenkov Mesh

1% Scale

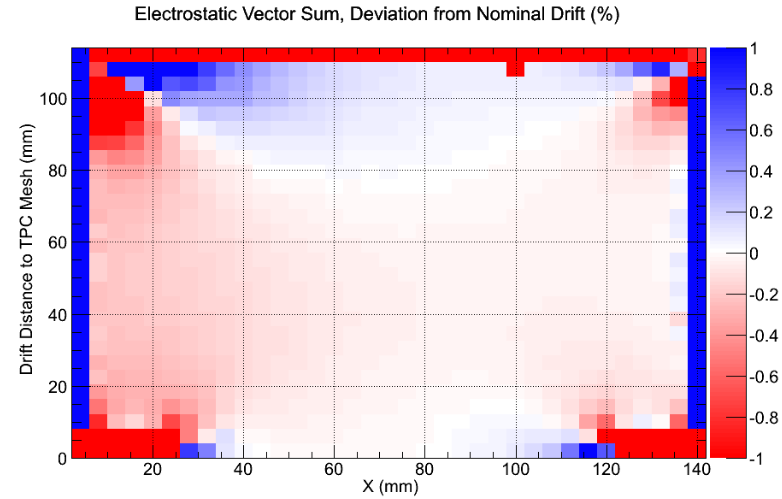
Drift

Wires

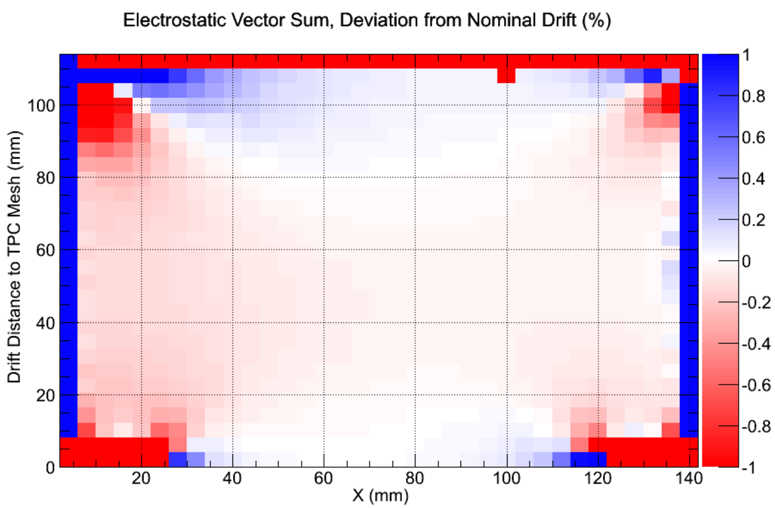
No Cherenkov mesh



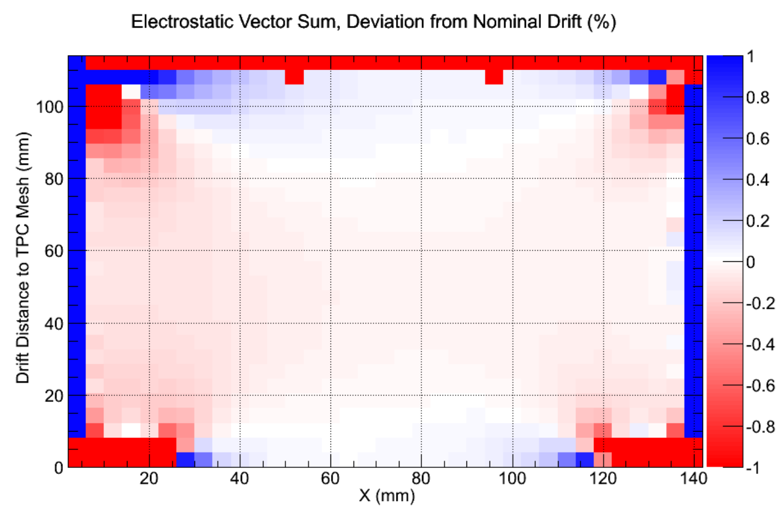
Cherenkov mesh @ -15 mm



Cherenkov mesh @ -25 mm

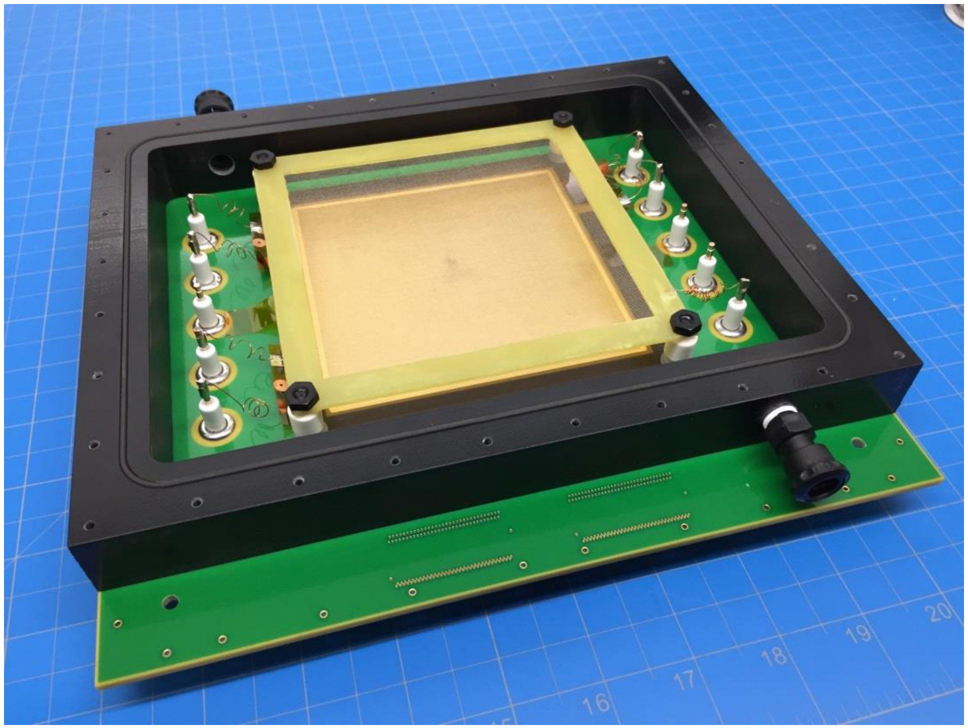


Cherenkov mesh @ -40 mm

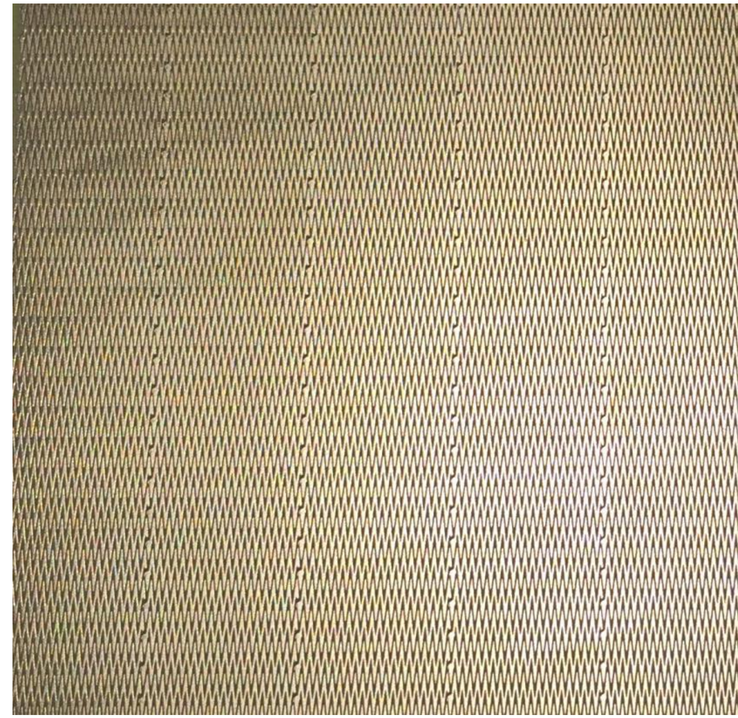


M.Phipps

TPC GEM Detector with Chevron readout board

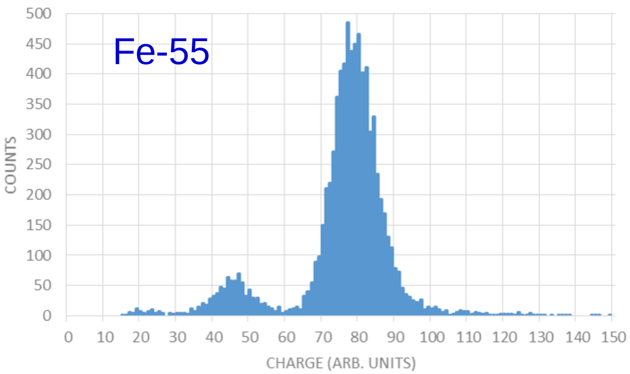


10x10 cm^2 Triple GEM

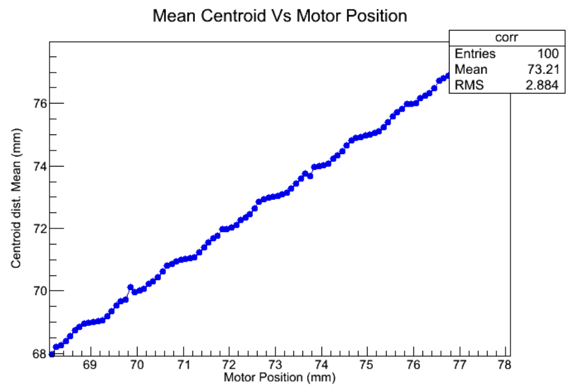


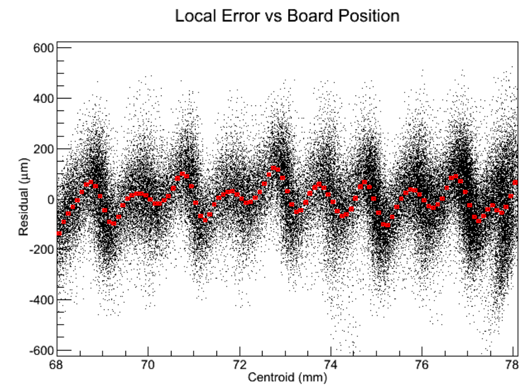
2 x10 mm Chevron Strips
0.5 mmm pitch

First Tests of the TPC GEM

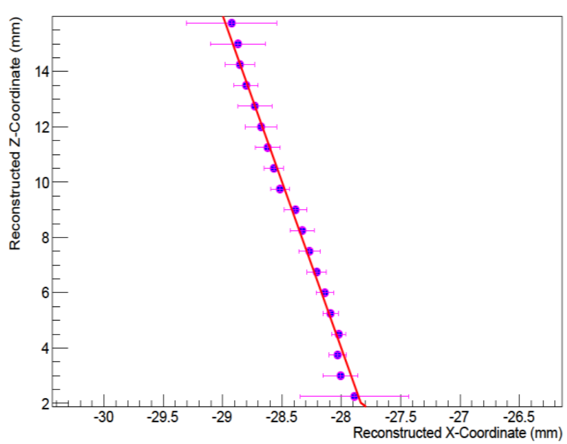


Scan across chevron pads with collimated X-ray source

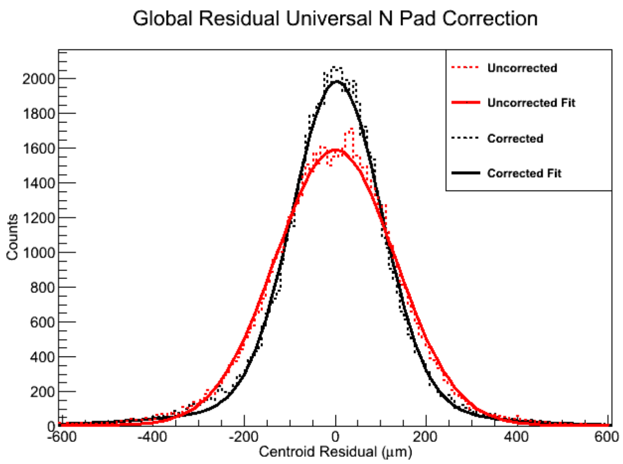




Reconstructed track with GEMs configured as a Minidrift Detector

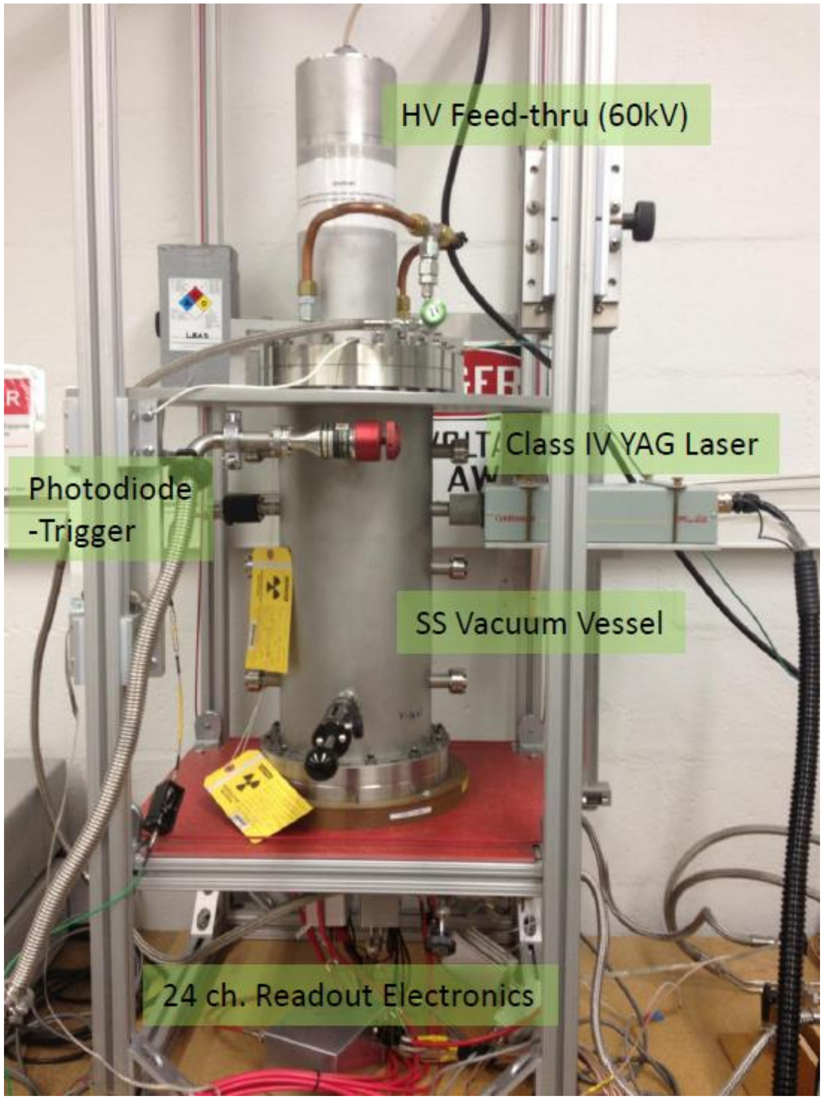


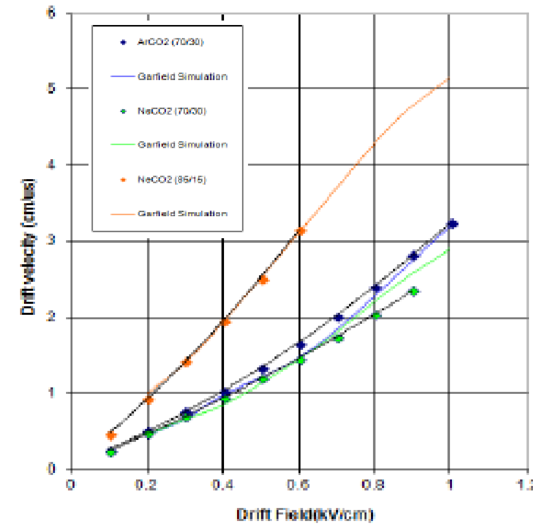
Position Resolution



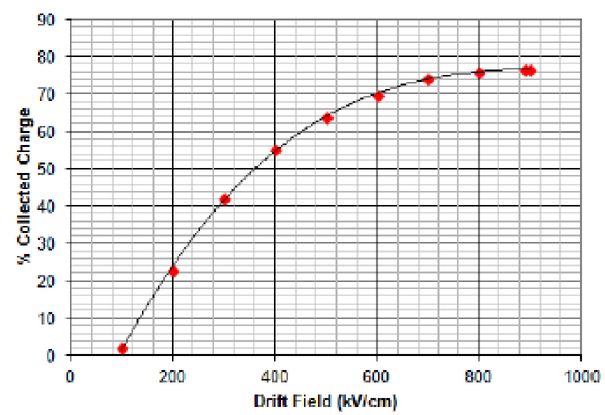
Uncorrected: 132 μm
Corrected: 98 μm

TPC Test Stand



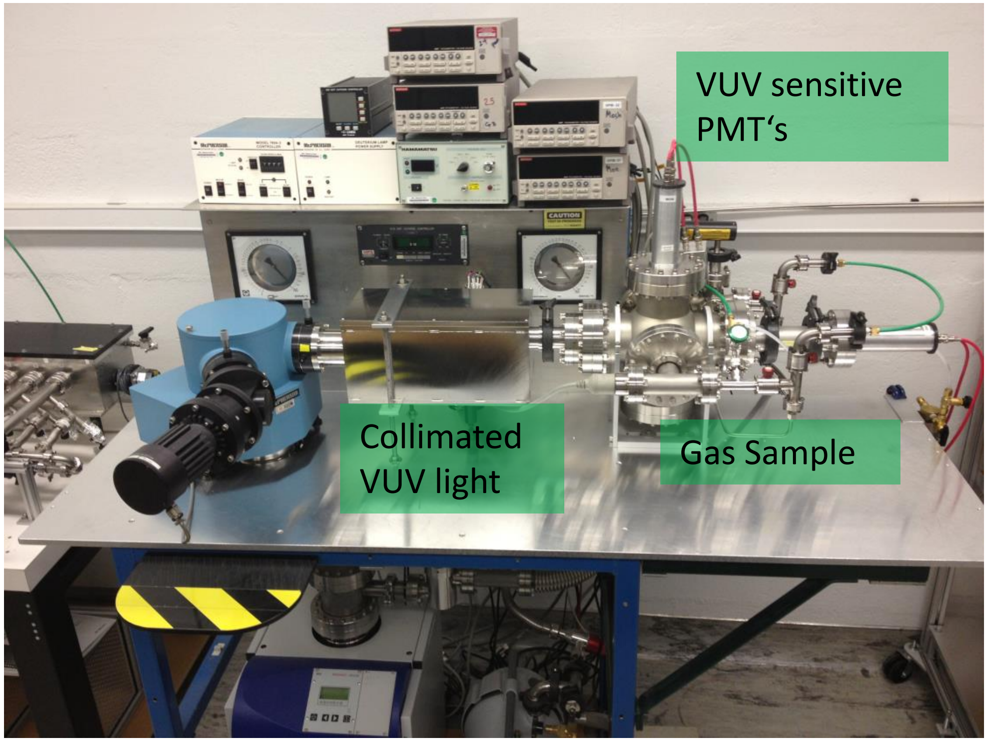


Drift velocity in Ar/CO_2/Ne gas mixtures,.

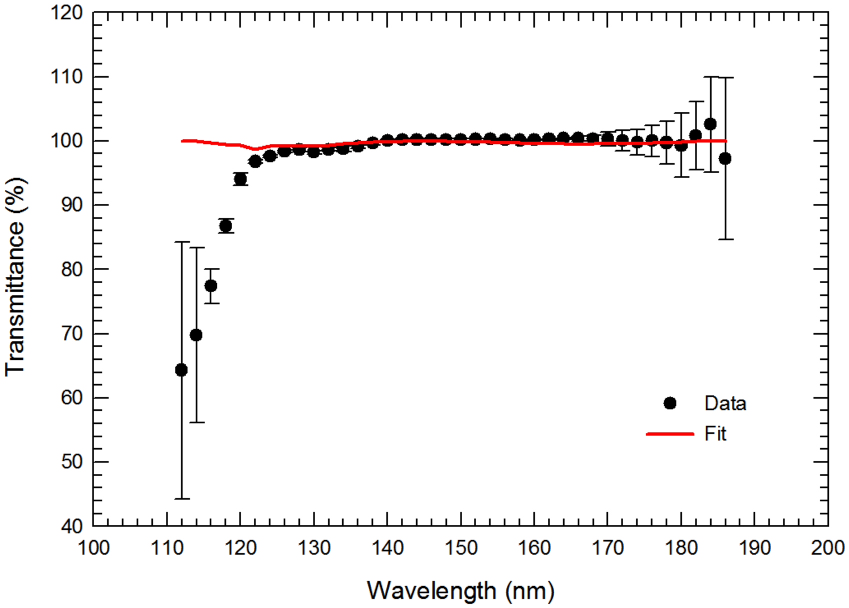


Charge attachment in Ar/CO_2 (70/30) over a 32 cm drift distance.

VUV Spectrometer



Transmittance of pure CF_4



Used to make measurements of:

- CsI QE
- Transmittance of gases into the deep UV
- Ion feedback measurements

Electronics

Current readout options

- SRS : 1024 chs, 25 ns sampling
  28 samples $\rightarrow$ 700 ns drift time
- DRS4 : 128 chs, 1048 samples with selectable time resolution
  0.2 ns $\rightarrow$ 200 ns drift time
  1 ns $\rightarrow$ 1 μsec drift time
- Struck SIS3300 : 24 chs, 10 ns sampling, 10 μsec drift time
- VMM2 (derived from LEGS TPC chip)
  Single peak amplitude recorded, 1 μsec time buffer
- GET: General Electronics for TPCs
  General purpose TPC readout system developed at Saclay
  Used in many small to medium sized TPC systems in nuclear physics
- SAMPA
  Being developed for ALICE GEM TPC
  Time scale: needs to be ready by 2018
  $\rightarrow$ This is probably our best ultimate solution

Summary & Future Plans

- Assembly of the prototype TPC/Cherenkov is complete
- Preliminary testing of the field cage and TPC GEMs look good
- Will test initially as a TPC only (no CsI GEM)
  This will really be a testing ground for learning how to operate a TPC
  Measure drift velocities, study ion feedback, reconstruct tracks, etc
- Add Cherenkov GEM (no CsI) and study HV effects
  How close can we bring the Č-GEM in proximity to the wire plane ?
- Add CsI GEM and study the Cherenkov detector
- Test entire detector in the test beam at Fermilab or SLAC